Spacelift Development Plan

SMC/XR Development Planning

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SDP Context within AFSPC LET Vision

AFSPC Vision

Focus of SDP for Near, Mid & Far Term

- Lighter and Leaner Operations
  - Right-sizing range infrastructure
- More Efficient LV Acquisition
  - Tailoring capability to today's needs
  - Posturing for tomorrow
- User-Needs Focused
  - EELV; NASA; NRO; Navy; MDA; Commercial
  - Telemetry most pressing user need
  - Optics, weather
- Total Force Integration
  - Take full advantage of Total Force

Public Safety; Assured Access; Mission Success

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Requirements & Drivers

Sources

- EELV ORD AFSPC 002-93-II
  - Performance (lbs) — LEO: 17,000; Polar: 41,000; GTO: 8,500; GEO: 13,500
  - Demonstrated reliability — 97% (heavy); 97.5% (all others)
  - Cost Reduction: 25% (threshold); 50% (objective)
- National Security Presidential Directive 40 (NSPD-40)
  - Dramatic improvement in reliability, responsiveness & cost
  - Encourage / facilitate U.S. commercial space transportation industry to support U.S. space transportation goals
- Spacelift "required force" roadmap*
  - EELV through 2029; Minotaur I/IV through 2019
  - Planned development for next-gen med-heavy launcher starts in FY15, with IOC in FY25
  - Planned devel for next-gen small launcher starts in FY14, with IOC in FY18

Responsive Launch, not formalized but likely to include

- ORS / PGS: 1-5 klb to LEO, equivalent
- Reconstitution / Augmentation "within days"
- Flexibility, adaptability, and assuredness

Spacelift Drivers

- [x] Performance
- [x] Reliability
- [x] Cost Reduction
- [ ] Dramatic Cost Reduction
- [ ] Responsiveness
- [ ] Lift flexibility

*Per FY10 Launch, Range, and Networks (LRN) Capability Plan (CP) draft, consistent with AFSPC FY10 Strategic Recapitalization Plan (SRP)

Affordable responsive lift for full range of payloads

Analysis of Future Systems

VEHICLE OPTIONS

- **Expendable**

- **Partly Reusable**
  - Reusable booster with expendable upper stages

- **Fully Reusable**
  - All Rocket (Two-Stage-to-Orbit (TSTO)
  - All Hypersonic (TBCC + RBCC)*
  - Rocket and Hypersonic (RBCC)

*TBCC = Turbine-Based Combined Cycle
*RBCC = Rocket-Based Combined Cycle

TECHNICAL FACTORS

- **Cost**
- **Reliability**
- **Reusability vs. expendability**
- **Mass fraction**
- **Margins**
- **Propulsive efficiency**
- **Operations**
- **Technology maturity**
- **Launch rates**
- **Responsiveness**

INFRASTRUCTURE

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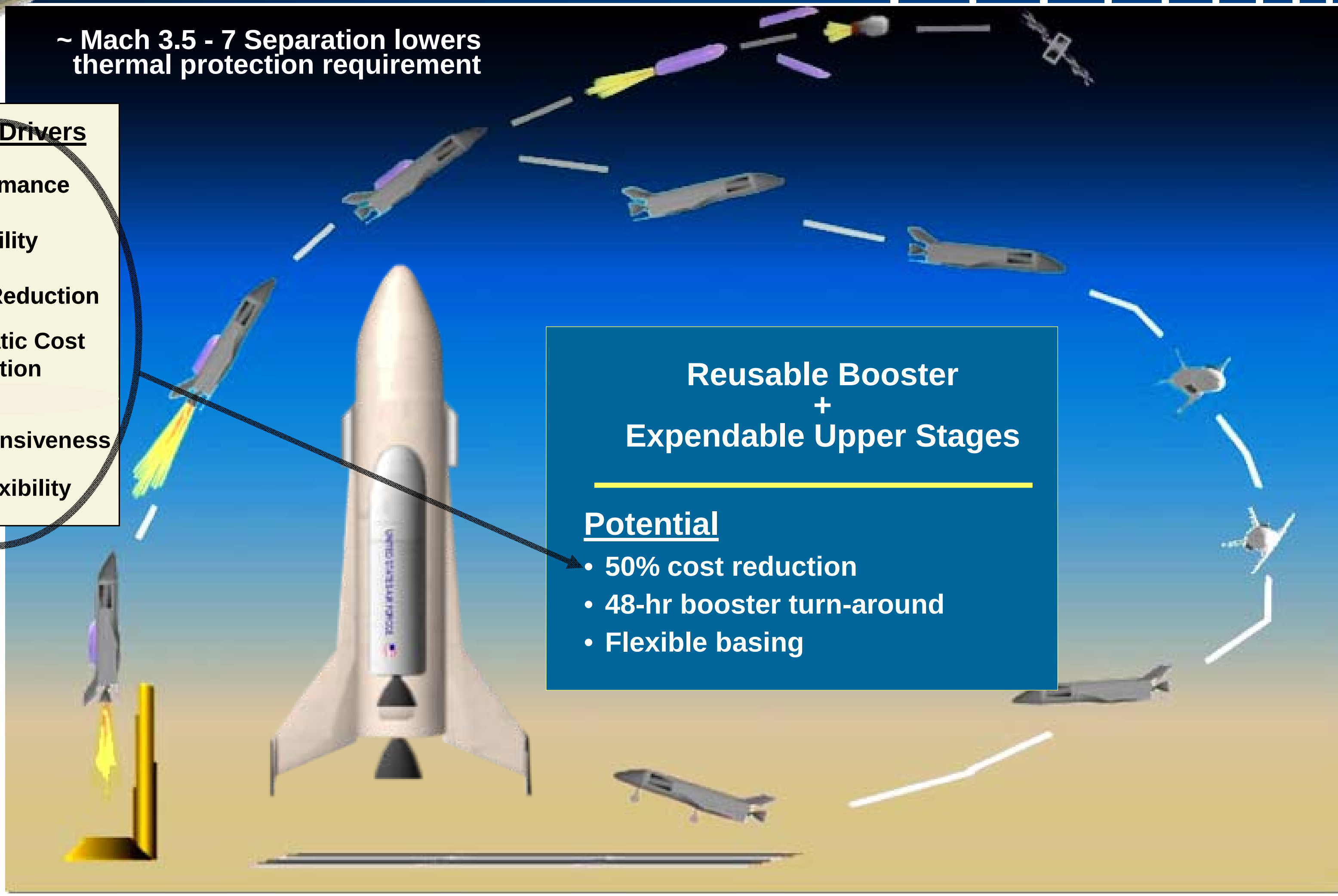
Reusable Booster System (RBS) Concept

~ Mach 3.5 - 7 Separation lowers
thermal protection requirement



<u>Spacelift Drivers</u>

- ☑ Performance
- ☑ Reliability
- ☑ Cost Reduction
- ☐ Dramatic Cost Reduction
- ☐ Responsiveness
- ☐ Lift flexibility

Reusable Booster
+
Expendable Upper Stages

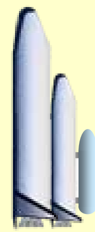
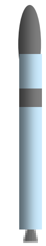
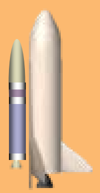
<u>Potential</u>

- 50% cost reduction
- 48-hr booster turn-around
- Flexible basing

Lowest life cycle cost for likely launch rates

Effects of Reusability and Expendability

(This example based on 15 Klb to LEO capability)

	RLV	ELV	RBS (Reusable Booster System)
			
Expended Hardware (Klb)	0	33	12
Reused Hardware (Klb)	196	0	61

Avoids 64% of ELV's expendable hardware

Avoids 69% of RLV's reusable hardware

Fully Reusable RLVs

- Are big (80% of orbited mass is the orbiter)
- Drives higher development cost

Fully Expendable ELVs

- Drives higher recurring costs
  - Production, Qual, Cert, & Ground Test
  - Mission Assurance

RBS

- Balance ELV-RLV production and development costs, resulting in lower LCC for most cases
- ~50% launch cost reduction

Reusable booster with expendable upper stages is an optimum combination to reduce launch cost.

Difference between Reusable 'Manned' Orbiter and 'Unmanned' Reusable Booster

Most labor-intensive systems are eliminated…

Subsystem	Shuttle Orbiter man-hrs/flight	Reusable Booster	Explanation
Thermal Protection Tiles (TPS)	18,914	10's of man-hours	Not needed. Thermal environment 20x less than orbiter.
Crew Support Systems	15,893	Subsystem Eliminated	Not needed. Reusable booster is an unmanned vehicle.
Toxic Aux. Power Unit (APU)	8,056	Subsystem Eliminated	Not needed. Batteries provide power for actuation.
H2/O2 Fuel Cells	2,487	Subsystem Eliminated	Not needed. Batteries provide power.
Orbital Maneuvering System (OMS)	3,848	Subsystem Eliminated	Not needed. No on-orbit operations.

Increasing margin increases system life

Block 1 Main Engines	R/R Every Flight	R/R Every 10^{th} Flight	15% Operating Margin – Longer Life

Eliminating orbit environment, short flight time, and increasing margins simplifies remaining systems

Hydraulics / On-Orbit Thermal Control / Reaction Control System / Data System / etc.

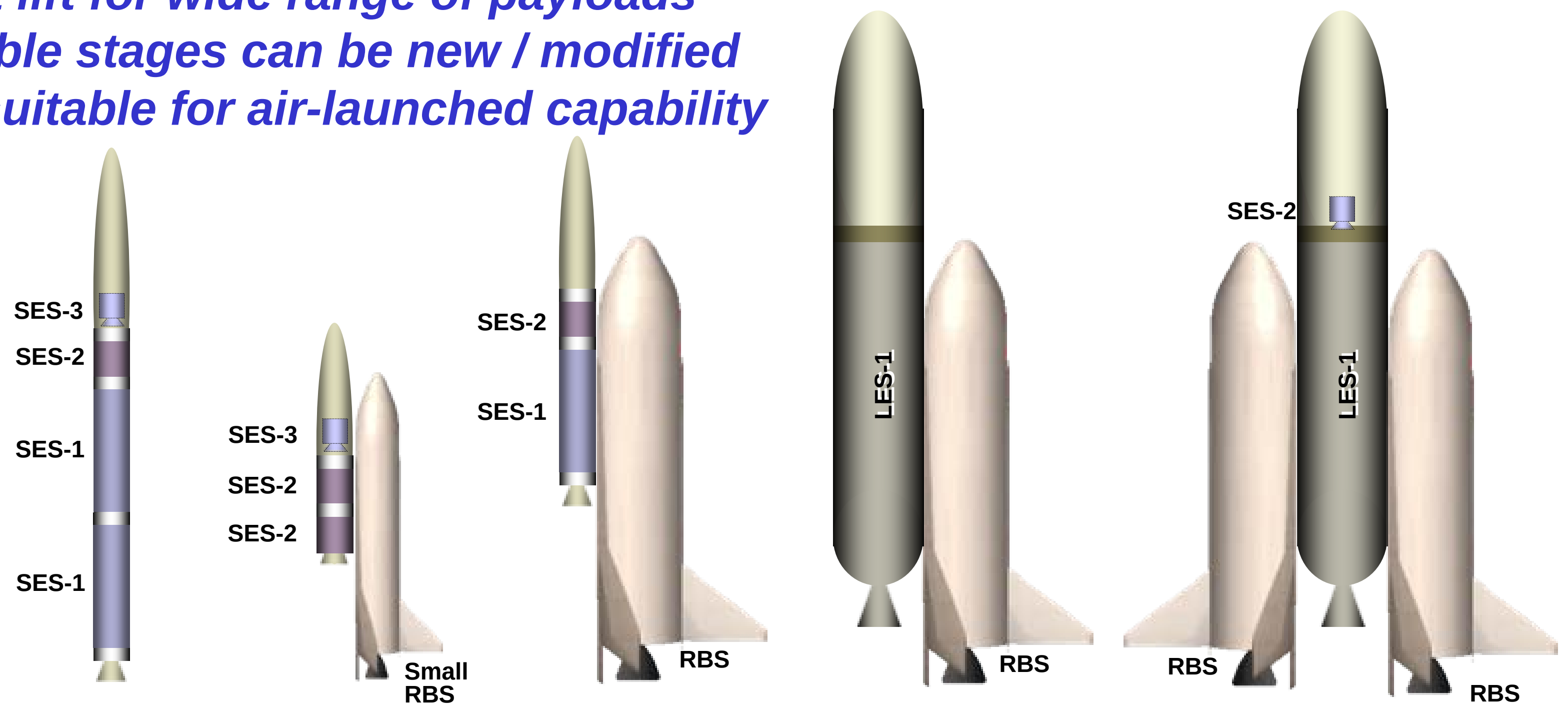
Reusable booster avoids complexities and maintenance needs of a reusable orbiter

Architecture Example

- *Modular architecture, utilizing a few common elements*
- *Low-cost lift for wide range of payloads*
- *Expendable stages can be new / modified*
  - *Also suitable for air-launched capability*

Spacelift Drivers

- ☑ Performance
- ☑ Reliability
- ☑ Cost Reduction
- ☑ Dramatic Cost Reduction
- ☑ Responsiveness
- ☑ Lift flexibility



	Small	Small	Med-Lite	Medium	Heavy
Lb to LEO	5,000	5,000	16,500	50,000	64,000
Cost savings	0	~33%	~50%	~50%	~50%
Approx IOC	2015-2020	2019	2025	2025	2030

SES = Small Expendable Stage, LES = Large Expendable Stage

Path to the Future: RBS Demo

AFRL Budget Supports
- FAST X-vehicle size ground experiment
- Sub X-vehicle class flight experiment

Cost & Ops databases

Safe return-to-base validation

Controllability characteristics

System integration and performance
- Structure / Tanks / Thermal
- Reusable Propulsion
- Mechanical / Electrical / Comm
- Design Tools
- Health Management for Quick Turn

Autonomous flight control demo

Upper stage sep characteristics data

Risk Reduction for operational system

Demos: Integrated Guidance & Control, Flight Structure, & Aero Flight

Gen. Kehler's Perspective

- On 20 Jan, SMC/XR briefed SDP to Gen. Kehler
- Gen. Kehler feedback:
  - Acknowledged RBS conceptual approach in lowering launch cost and improving responsiveness
  - Supports AFRL funded RBS demonstration to verify affordability and operability estimates
  - Socialize the SDP with the National Security Space Enterprise and NASA
- Gen. Kehler direction:
  - Expand SDP to provide a comprehensive plan that encompasses a wider set of missions, e.g., NASA, strike, missile defense, and commercial
    - Must address space debris control/abatement and other political requirements
  - No decision on EELV follow-on until integrated SDP is complete/approved
  - A5 to develop revised (broader) Initial Capabilities Document (ICD)
  - AFSPC/SMC to investigate FY12 POM opportunities to partner with AFRL and increase RBS demo capability

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SDP Way Ahead

- Socialize SDP with National Security Space Enterprise
  - **USECAF**
  - **SAF/USA**
  - **OSD ATL**
  - **NRO**
  - **AF-NASA Partnership Council**
- Coordinate with NASA, MDA, & PGS
  - **Expand the SDP ICD Requirements**
- Obtain industry input
  - **Industry Day**
- Establish demonstrator as top technology priority
  - **Form team to plan demonstrator risk reduction, demonstrator objectives, and required funding**